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Space Image of the Week
1. Get Up Early, See Five Planets at Once!

If you follow celestial comings and goings at all, you know that bright planets have been largely missing from the evening sky for a few months. Sure, with careful watching you could have spotted Saturn low in the southwest as late as November, and Mercury put in a brief appearance a few weeks ago.

But really all the action has been in the sky before sunrise. Anchored by bright Venus and Jupiter, joined by Mars and Saturn, this planetary fab four has been dominating skywatchers' attention for months. (Did you catch last October's triple play involving Venus, Jupiter, and Mars?)

The show far from over. In fact, during the next two weeks you'll have a good chance to view five planets at once. It's a real visual treat, so don't pass up the chance to see it.

(You might see posts elsewhere that suggest this event runs from January 20th to February 20th. Technically, that's true — in his book More Mathematical Morsels, celestial dynamical Jean Meeus notes these dates. But realistically you're not going to see Mercury for a whole month. Instead, I suggest that the last week of January and first week of February are your "best bets" for success.)

Let's set the stage. You'll need to be outside about 45 minutes before sunrise. This time of year, if you work or go to school, you're usually already up by then — maybe even well positioned to scan the predawn eastern horizon as you commute to work or head off to school.

Venus is obvious as it lingers above the southeastern horizon. It's actually in decline, not nearly as high up as you saw it toward the end of 2015. But Venus has no equal for brightness among the night's planets and stars. Way over to the right, on the southwestern side of the sky, is Jupiter. In between are four bright beacons: not far from Venus are Saturn and, below it, the star Antares. Shift your gaze farther right to sweep up Mars, then the star Spica, and finally Jupiter.

The fifth planet is Mercury, which was spotable low in the southwest after sunset just two weeks ago. But it's been racing rapidly from evening to morning visibility. (The fleetest of planets can do that, since it circles the Sun in just 88 days.) Your first good chance to spot Mercury before dawn comes later this week. By Friday, the
22nd, find a clear view toward southeast and look 5° above the horizon. That's about the width of your three middle fingers held together at arm's length. It's along a diagonal from Saturn through Venus, about as far from Venus as Saturn is. Day by day, Mercury will appear a little higher up and a little brighter. By month's end, it'll be easy to spot.

**A Plane of Planets**

As you sweep your gaze from Mercury toward Jupiter, an arc of roughly 110°, notice that all these planets line along a single arc across the sky. That's no accident. All of the major planets lie very near the plane of Earth's orbit, which projects as a line — the *ecliptic* — across the sky. By definition, the Sun always lies on the ecliptic — and our Moon is never far from it either. It's the superhighway of planetary motion among the stars.

As you're gazing at all these planets, think about their varied distances from us? Astronomers use the average Earth-Sun distance, called an *astronomical unit*, as a handy yardstick for intra-solar-system distances. Of the five planets you're seeing, right now Mercury is closest (about 0.8 a.u.), followed by Venus (1.3), Mars (1.4), Jupiter (4.7) and Saturn (10.6). The reflected sunlight you see coming from Mercury took a brief 6½ minutes to reach Earth, where that from Saturn took just under 1½ *hours* to get here.

But don't let the vastness of interplanetary space keep you from enjoying for the simple visual beauty that awaits you before dawn. We haven't had this opportunity since this time 11 years ago. Back then their order in the sky briefly matched their relative order outward from the Sun. This time, Mars and Saturn apparently didn't get the memo, but we'll happily overlook that, right?

Source: [Sky & Telescope](#)
A SpaceX Falcon 9 rocket successfully launched an ocean science satellite Jan. 17, although an attempt to land the rocket's first stage on a ship apparently failed.

The Falcon 9 v1.1 rocket lifted off from Vandenberg Air Force Base in California at 1:42 p.m. Eastern. The vehicle's upper stage placed the Jason-3 spacecraft into a parking orbit nine minutes after launch, and the spacecraft separated from the upper stage 56 minutes after liftoff, after a second, brief burn by the upper stage.

The status of a secondary objective of the launch, the landing of the rocket's first stage, was not immediately known. A video feed from the company's “droneship,” located nearly 300 kilometers downrange from the launch site, cut out seconds before the stage was to attempt a landing.

A SpaceX spokesman said on the company's webcast of the launch a short time later that the first stage was on target to land on the ship, but came in too hard. “It looks like one of the landing legs may have broken as we touched down on the droneship,” he said. “Unfortunately we are not standing upright on the droneship at the moment.”

SpaceX Chief Executive Elon Musk later tweeted that a problem with a landing leg, and not a hard landing, caused the vehicle to topple. “Touchdown speed was OK, but a leg lockout didn't latch, so it tipped over after landing,” he said.

Musk later tweeted a photo of debris of the Falcon 9 first stage on the droneship. “Well, at least the pieces were bigger this time!” he said. “Won't be last RUD [rapid unscheduled disassembly], but am optimistic about upcoming ship landing.”

Late Jan. 17, Musk posted a brief video showing the landing. In the video, the stage appears to make a successful landing on the ship, only to topple over when one of four landing legs gives way. Musk speculated
that ice buildup, linked to fog that socked in the launch site in the hours leading up to launch, may have kept
the leg from locking properly.

The launch was the first Falcon 9 mission for SpaceX from Vandenberg since the September 2013 launch of
the first Falcon 9 v1.1 rocket, carrying the Canadian Cassiope satellite. This mission is also the last launch of
the Falcon 9 v1.1, as SpaceX switches to an upgraded version that first flew in December.

The launch was also the first SpaceX launch under NASA's Launch Services Program (LSP), which contracts for
the launch of NASA-sponsored spacecraft separately from the agency's commercial cargo and crew programs.
That gave the agency oversight into launch preparations, including the investigation into the June 2015 failure
of a Falcon 9 carrying a Dragon cargo spacecraft.

NASA LSP carried out its own investigation into the launch failure. “We had the SpaceX investigation and the
LSP investigation. They both came together very well,” said Akash Vangani, NASA LSP certification manager, in
a NASA TV interview Jan. 17. “There were a number of things that were found throughout both investigations
that we had to resolve and mitigate, which led to quite a few hardware changes over the past few months.”

Jason-3 is the latest in a series of ocean monitoring satellites dating back more than two decades. The mission
is a joint venture of several agencies in the U.S. and Europe, including NASA, the National Oceanic and
Atmospheric Administration, the French space agency CNES and European weather satellite operator
Eumetsat.

The 510-kilogram satellite will be placed into a near-polar orbit, ultimately at an altitude of 1,336 kilometers,
the same orbit as that used by the current Jason-2 spacecraft. Jason-3 will work in conjunction with Jason-2
for at least six months to calibrate data from the new spacecraft’s instruments.

Jason-3 is designed to continue the collection of data on ocean surface conditions that play an essential role in
both weather forecasting and climate monitoring. “Jason information is incredibly useful, especially to NOAA,
because it allows us to not only track the sea level change that is impacting our coastal features right now, but
also to help forecast extreme weather,” said Laury Miller, Jason-3 program scientist at NOAA, during a pre-
launch press conference Jan. 15.
3. Seeing Shadows of Ancient Galaxies

Most of the universe is hidden from view. The world’s best telescopes can’t pick up rocky asteroids that orbit the far reaches of the solar system, exoplanets that circle distant stars, or galaxies that formed in the early universe. Instead, science is often done in silhouette. Astronomers spot such evasive objects only by the shadow they cast when they pass, by chance, in front of a more distant light source.

A new study improves upon that method, bringing to light so-called damped lyman-alpha systems, giant clouds made mostly of hydrogen gas in the early universe. Jeff Cooke (Swinburne Institute of Technology, Australia) and John O’Meara (Saint Michael’s College) announced at the American Astronomical Society meeting in Kissimmee, Florida, that they’ve found one of these clouds that spans three times the width of the Milky Way.

Because neutral hydrogen emits no radiation, damped lyman-alpha systems are notoriously difficult to detect directly. Instead, astronomers use a simple trick: they catch the clouds’ shadows. The flood of light from distant quasars — a class of intensely bright galactic cores with supermassive black holes that are gobbling down gas and dust — casts a spotlight on otherwise invisible gas. Any intervening hydrogen atoms absorb a specific wavelength of the quasar’s light, leaving a dark absorption line in the spectrum that reaches Earth.

The shape and depth of that absorption line reveals some information about the intervening cloud. Astronomers now know, for example, that a similar total amount of hydrogen gas exists in these early clouds as in the interstellar medium of most galaxies today. As such, they’re a good proxy for the star-forming regions within galaxies in the early universe. Detailed measurements of these clouds could therefore shed light on how galaxies form and evolve.

How Big Are They?

To date, astronomers have used absorption lines within quasars’ light to study thousands of damped lyman-alpha systems. But there’s one big disadvantage. Because quasars themselves are very small objects, only a few light-years across, astronomers can only probe a tiny portion of these systems. Cooke compared this problem to illuminating a massive college campus with just the tip of a laser pointer. You’ll likely only spot a blade of grass or a sliver of a cement rooftop.

“For 40 years we’ve been using this technique to understand gas in early galaxies, but we’ve been missing out on two really important, fundamental pieces of information,” says O’Meara: the clouds’ sizes and masses. “That’s kind of embarrassing.” As such, astronomers are unaware if these systems are just small clouds within a galaxy or massive clouds within the intergalactic medium that are ready to form a galaxy.

So Cooke (pronounced like the treat) and O’Meara decided to look for background galaxies instead. A larger background light source will illuminate far more — if not all — of an intervening cloud and reveal unprecedented detail. Distant galaxies are usually too faint to use as spotlights, but the technique becomes feasible with larger telescopes coming online in the near future.
As a proof of concept Cooke and O'Meara looked for damped lyman-alpha systems in the signatures of 54 bright galaxies using the Keck Observatory's twin 10-meter telescopes and the Very Large Telescope's four 8.2-meter dishes. One galaxy, known as VVDS 910298177 (located at a time when the universe was only 3 billion years old), clearly showed a damped lyman-alpha system. The absorption line drops all the way to zero all the way across the background galaxy, which means that the gigantic cloud in front of it must cover the whole thing. That makes the cloud at least three times the size of the Milky Way — much larger than astronomers could have guessed given a background quasar.

“So what we've done is increased our ability of understanding the size of things by about a factor of a hundred million, which is really kind of cool,” says O'Meara.

The finding might help solve the puzzle of where these early clouds reside. "The damped lyman-alpha systems we've found appear to be essentially 'standalone' clouds in the intergalactic medium," says Cooke. They are so large that they "will likely form full mature galaxies like the present-day spiral galaxies like the Milky Way."

Dawn Erb (University of Wisconsin Milwaukee), who was not involved in the study, thinks the method will be a useful complement to the work she does. Erb studies galaxies at similar cosmological distances, but she does so by looking at their emitted light, rather than their absorbed light. By looking at these galaxies in both emission and absorption, she says, astronomers can gain a far better understanding of their overall morphologies.

Shadow of an Ancient Galaxy

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The new technique holds a lot of promise in the era of 30-meter telescopes. “These monster-machines that are getting built are going to be able to use this technique by the thousands,” says O’Meara. And they’ll do so much more in 18 hours than Cooke and O’Meara were able to accomplish on the Very Large Telescope. There are far more galaxies than quasars in the first place, so soon enough astronomers will be able to “map out a three-dimensional tomography of all of the gas in the universe,” says Cooke.
The Night Sky

Tuesday, January 19

• The dark limb of the waxing gibbous Moon occults Aldebaran this evening for most of North America. See the time-prediction maps in the January Sky & Telescope, page 49. You can also get local timetables for the star’s disappearance and reappearance. The Moon will be 82% sunlit.

Wednesday, January 20

• Sirius twinkles brightly after dinnertime below Orion in the southeast, far below the Moon. Sometime around 8 or 9 p.m., depending on your location, Sirius shines precisely below fiery Betelgeuse in Orion’s shoulder. How accurately can you time this event for your location, perhaps using a plumb bob or the vertical edge of a building? Sirius leads early in the evening, Betelgeuse leads later.

Thursday, January 21

• Tonight the 9.9-magnitude asteroid 115 Thyra will briefly occult a 9.0-magnitude star near the Beehive cluster in Cancer for telescope users along a narrow track from southern New Jersey through the San Diego area. Watch them merge before their combined light suddenly drops by 1.3 magnitudes for up to 7 seconds. Track map, finder charts, time predictions.

Friday, January 22

• The nearly-full Moon shines in Gemini this evening, with Castor and Pollux to its upper left and brighter Procyon to its lower right, as shown here.

• On the other side of the sky, the big Northern Cross of Cygnus plants itself upright on the northwest horizon soon after the end of twilight.

Source: Sky & Telescope
ISS Sighting Opportunities

**For Denver:**

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Sighting information for other cities can be found at NASA’s [Satellite Sighting Information](https://nssdc.gsfc.nasa.gov/spaceflight/iss/iss_sighting.html).

**NASA-TV Highlights**

*all times Eastern Daylight Time*

- **9 a.m., Wednesday, January 20** - ISS Expedition 46 In-Flight Interviews for Voice of America and Westwood One Radio Network with Commander Scott Kelly of NASA and Flight Engineer Mikhail Kornienko of Roscosmos (starts at 9:20) (all channels)
- **6 a.m., Friday, January 22** - Live Media Satellite Interviews on the James Webb Space Telescope (NTV-3 (Media))
- **1 p.m., Thursday, January 28** - ISS Expedition 46 In-Flight Interviews for TBD and the Military Times with Commander Scott Kelly

Watch NASA TV on the Net by going to the [NASA website](https://nasa.gov).
Space Calendar

- Jan 19 - Comet P/2015 P4 (PANSTARRS) Perihelion (2.525 AU)
- Jan 19 - Comet 73P-AH/Schwassmann-Wachmann At Opposition (3.052 AU)
- Jan 19 - Comet 73P-AN/Schwassmann-Wachmann At Opposition (3.066 AU)
- Jan 19 - Comet 73P-L/Schwassmann-Wachmann At Opposition (3.067 AU)
- Jan 19 - Comet 73P-X/Schwassmann-Wachmann At Opposition (3.069 AU)
- Jan 19 - Comet C/2015 V4 (PANSTARRS) At Opposition (5.168 AU)
- Jan 19 - Asteroid 1772 Gagarin Closest Approach To Earth (1.418 AU)
- Jan 19 - Asteroid 5249 Giza Closest Approach To Earth (1.940 AU)
- Jan 19 - Kuiper Belt Object 20000 Varuna At Opposition (42.814 AU)
- Jan 19 - 10th Anniversary (2006), New Horizons Launch (Pluto Mission)
- Jan 19 - 15th Anniversary (2001), Mars Odyssey Cleanroom Leak
- Jan 19 - Jacobus Kapteyn's 165th Birthday (1851)
- Jan 20 - Comet 211P/Hill At Opposition (1.367 AU)
- Jan 20 - Comet 133P/Elst-Pizarro Closest Approach To Earth (2.679 AU)
- Jan 20 - Comet 133P/Elst-Pizarro At Opposition (2.679 AU)
- Jan 20 - Comet 73P-R/Schwassmann-Wachmann At Opposition (3.004 AU)
- Jan 20 - Comet 73P-Z/Schwassmann-Wachmann At Opposition (3.019 AU)
- Jan 20 - Comet 73P-AO/Schwassmann-Wachmann At Opposition (3.019 AU)
- Jan 20 - Comet 73P-M/Schwassmann-Wachmann At Opposition (3.067 AU)
- Jan 20 - Atira Asteroid 2013 TQ5 Closest Approach To Earth (0.300 AU)
- Jan 20 - Asteroid 253 Mathilde Closest Approach To Earth (2.187 AU)
- Jan 20 - Asteroid 13586 Copenhagen Closest Approach To Earth (2.261 AU)
- Jan 20 - Louis Boyer's 115th Birthday (1901)
- Jan 21 - Comet 73P/Schwassmann-Wachmann At Opposition (2.936 AU)
- Jan 21 - Comet 73P-C/Schwassmann-Wachmann At Opposition (2.936 AU)
- Jan 21 - Comet 73P-G/Schwassmann-Wachmann At Opposition (2.939 AU)
- Jan 21 - Comet 73P-K/Schwassmann-Wachmann At Opposition (2.948 AU)
- Jan 21 - Comet 73P-B/Schwassmann-Wachmann At Opposition (2.949 AU)
- Jan 21 - Comet 73P-H/Schwassmann-Wachmann At Opposition (2.953 AU)
- Jan 21 - Comet 73P-AD/Schwassmann-Wachmann At Opposition (2.978 AU)
- Jan 21 - Comet C/2016 A3 (PANSTARRS) At Opposition (4.297 AU)
- Jan 21 - Apollo Asteroid 2016 AF166 Near-Earth Flyby (0.024 AU)
- Jan 21 - Apollo Asteroid 2011 BG24 Near-Earth Flyby (0.080 AU)
- Jan 21 - Asteroid 246913 Slocum Closest Approach To Earth (1.636 AU)
- Jan 21 - Asteroid 39415 Ianeausten Closest Approach To Earth (3.739 AU)
- Jan 22 - Comet 73P-AU/Schwassmann-Wachmann At Opposition (2.883 AU)
- Jan 22 - Comet 73P-AK/Schwassmann-Wachmann At Opposition (2.887 AU)
- Jan 22 - Comet 73P-AV/Schwassmann-Wachmann At Opposition (2.922 AU)
- Jan 22 - Comet 73P-E/Schwassmann-Wachmann At Opposition (2.972 AU)
- Jan 22 - Comet 73P-AS/Schwassmann-Wachmann Closest Approach To Earth (3.588 AU)
- Jan 22 - Comet 73P-AP/Schwassmann-Wachmann Closest Approach To Earth (3.624 AU)
- Jan 22 - Comet P/2001 F1 (NEAT) Closest Approach To Earth (3.801 AU)
- Jan 22 - Apollo Asteroid 1685 Toro Closest Approach To Earth (0.157 AU)
- Jan 22 - Asteroid 10183 Ampere Closest Approach To Earth (1.078 AU)
- Jan 22 - Asteroid 5203 Pavarotti Closest Approach To Earth (1.662 AU)
- Jan 22 - Asteroid 30785 Greeley Closest Approach To Earth (1.909 AU)
- Jan 22 - Plutino 208996 (2003 AZ84) At Opposition (43.827 AU)

Source: JPL Space Calendar
Standard cosmology -- that is, the Big Bang Theory with its early period of exponential growth known as inflation -- is the prevailing scientific model for our universe.

It suggest that he entirety of space and time ballooned out from a very hot, very dense point into a homogeneous and ever-expanding vastness. This theory accounts for many of the physical phenomena we observe. But what if that's not all there was to it?

A new theory from physicists at the U.S. Department of Energy's Brookhaven National Laboratory, Fermi National Accelerator Laboratory, and Stony Brook University, which will publish online on January 18 in Physical Review Letters, suggests a shorter secondary inflationary period that could account for the amount of dark matter estimated to exist throughout the cosmos.

"In general, a fundamental theory of nature can explain certain phenomena, but it may not always end up giving you the right amount of dark matter," said Hooman Davoudiasl, group leader in the High-Energy Theory Group at Brookhaven National Laboratory and an author on the paper. "If you come up with too little dark matter, you can suggest another source, but having too much is a problem."

Measuring the amount of dark matter in the universe is no easy task. It is dark after all, so it doesn't interact in any significant way with ordinary matter. Nonetheless, gravitational effects of dark matter give scientists a good idea of how much of it is out there. The best estimates indicate that it makes up about a quarter of the mass-energy budget of the universe, while ordinary matter -- which makes up the stars, our planet, and us -- comprises just 5 percent. Dark matter is the dominant form of substance in the universe, which leads physicists to devise theories and experiments to explore its properties and understand how it originated.
Some theories that elegantly explain perplexing oddities in physics -- for example, the inordinate weakness of gravity compared to other fundamental interactions such as the electromagnetic, strong nuclear, and weak nuclear forces -- cannot be fully accepted because they predict more dark matter than empirical observations can support.

This new theory solves that problem. Davoudiasl and his colleagues add a step to the commonly accepted events at the inception of space and time.

In standard cosmology, the exponential expansion of the universe called cosmic inflation began perhaps as early as 10^-35 seconds after the beginning of time -- that's a decimal point followed by 34 zeros before a 1. This explosive expansion of the entirety of space lasted mere fractions of a fraction of a second, eventually leading to a hot universe, followed by a cooling period that has continued until the present day. Then, when the universe was just seconds to minutes old -- that is, cool enough -- the formation of the lighter elements began. Between those milestones, there may have been other inflationary interludes, said Davoudiasl.

"They wouldn't have been as grand or as violent as the initial one, but they could account for a dilution of dark matter," he said.

In the beginning, when temperatures soared past billions of degrees in a relatively small volume of space, dark matter particles could run into each other and annihilate upon contact, transferring their energy into standard constituents of matter - particles like electrons and quarks. But as the universe continued to expand and cool, dark matter particles encountered one another far less often, and the annihilation rate couldn't keep up with the expansion rate.

"At this point, the abundance of dark matter is now baked in the cake," said Davoudiasl. "Remember, dark matter interacts very weakly. So, a significant annihilation rate cannot persist at lower temperatures. Self-annihilation of dark matter becomes inefficient quite early, and the amount of dark matter particles is frozen."

However, the weaker the dark matter interactions, that is, the less efficient the annihilation, the higher the final abundance of dark matter particles would be. As experiments place ever more stringent constraints on the strength of dark matter interactions, there are some current theories that end up overestimating the quantity of dark matter in the universe. To bring theory into alignment with observations, Davoudiasl and his colleagues suggest that another inflationary period took place, powered by interactions in a "hidden sector" of physics. This second, milder, period of inflation, characterized by a rapid increase in volume, would dilute primordial particle abundances, potentially leaving the universe with the density of dark matter we observe today.

"It's definitely not the standard cosmology, but you have to accept that the universe may not be governed by things in the standard way that we thought," he said. "But we didn't need to construct something complicated. We show how a simple model can achieve this short amount of inflation in the early universe and account for the amount of dark matter we believe is out there."

Proving the theory is another thing entirely. Davoudiasl said there may be a way to look for at least the very feeblest of interactions between the hidden sector and ordinary matter.

"If this secondary inflationary period happened, it could be characterized by energies within the reach of experiments at accelerators such as the Relativistic Heavy Ion Collider (RHIC) and the Large Hadron Collider," he said. Only time will tell if signs of a hidden sector show up in collisions within these colliders, or in other experimental facilities.
Possible Ice Volcano on Pluto Has the ‘Wright Stuff’

Scientists with NASA’s New Horizons mission have assembled this highest-resolution color view of one of two potential cryovolcanoes spotted on the surface of Pluto by the New Horizons spacecraft in July 2015. This feature, known as Wright Mons, was informally named by the New Horizons team in honor of the Wright brothers. At about 90 miles (150 kilometers) across and 2.5 miles (4 kilometers) high, this feature is enormous. If it is in fact a volcano, as suspected, it would be the largest such feature discovered in the outer solar system.

Mission scientists are intrigued by the sparse distribution of red material in the image and wonder why it is not more widespread. Also perplexing is that there is only one identified impact crater on Wright Mons itself, telling scientists that the surface (as well as some of the crust underneath) was created relatively recently. This in turn may indicate that Wright Mons was volcanically active late in Pluto’s history.

Source: NASA